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The Logical Future Development of Research in Agricultural Engineering[1]

By R W Trullinger[2]

IT IS A SOMEWHAT speculative procedure to attempt to lay down a policy governing the logical future development of research in agricultural engineering with the expectation that it will be adhered to universally. Any such policy must be sufficiently broad and elastic to adequately meet the requirements of the widely varying and rapidly changing conditions and circumstances of national agriculture.

Under any conditions, however, research represents an investment of funds and personnel, and as such should yield a satisfactory return on the dollar. It would appear, therefore, that this business principle should govern the inauguration and conduct of agricultural-engineering research, and that the duration of this type of research should depend upon its ability to produce a valuable return in the shape of new knowledge of direct benefit to agriculture. In fact, this basic principle seems applicable to agricultural-engineering research regardless of the situation or surrounding circumstances and is recommended as a logical general policy governing all future undertakings of this character.

THE RESEARCH PROBLEM

Perhaps the first and most important single consideration in establishing a business-like policy governing the future development of research in agricultural engineering is the recognition and selection of problems needing solution. Without a well-defined, clear-cut problem representing a deficiency in the knowledge of some important agricultural practice, the undertaking of research may become a meaningless although highly ornamental thing.

It is not enough to study the draft of plows, the drainage or irrigation of crops, or the design of farm buildings. Any of these might develop into a study of considerable scientific profundity, but unless the end-result could be put to direct use in improving a specific detail of some agricultural practice, there might be some question as to the justification for the work as a business venture. On the other hand, if these subjects are studied to solve specific problems of tilth or reclamation under definite conditions of soil, crop, climate, and the like, or involve the development of economical and durable structures for the housing of a certain type and breed of animal, or the storage of a certain crop under known climatic and other conditions, the problem then becomes a concrete limited thing which can be understood at a glance.

This would not eliminate a class of fundamental problems which appear general, but frequently become important for both public and private research agencies in agricultural engineering to study. For example, the fundamental solution of soil dynamics, as it relates to stress distribution in soils under the impulse of traction and tillage elements of machinery, is of universal importance in agriculture. The fundamental analysis of wheels to determine the distribution of stresses in them as a basis for design is also universally important in the development of agricultural machinery. The same may be said of universal joints, steering mechanism, and the like, each of which needs the development of a basic theory to govern its application to specific agricultural uses. For example, the theory of steering mechanisms is of primary importance in the incorporation of stability in tractors for use on side hills and across gullies with steep approaches. All of these problems can be made of very definite character with the objective of serving a very specific agricultural requirement.

Thus a research problem in agricultural engineering is a specific thing, the solution of which is intended to serve a very definite purpose. That purpose is primarily agricultural and secondarily engineering in character, and it should be clearly defined at the outset. It was for this

[1]A paper presented at a session of College Division during the 26th annual meeting of the American Society of Agricultural Engineers at Ohio State University, Columbus, June 1932.

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Future research in agricultural engineering will be a highly coordinated undertaking between engineers and the commodity groups of agricultural scientists; between local, regional and national bodies; between public and private interests

reason that the Committee on Experiment Station Organization and Policy of the Association of Land-Grant Colleges and Universities recommended that the title of a research undertaking should characterize the concrete limited unit of work to be undertaken and that the objective should be clear cut and specific. The outlook for the undertaking should be constructive in character, take account of the status of the question, and indicate what specifically it is proposed to add to the sum of knowledge of the agricultural practice under study.

While a problem for research may come directly from the farmer or indirectly through commodity branches of agricultural research or the extension service, it would seem that it should be presented, in all its aspects, more completely and more plainly by the commodity branches. This would imply intimate and complete coordination of the research agencies in agricultural engineering with the commodity branches of agricultural research, particularly in the identification and selection of problems for research treatment. In this connection also a few of the leading agricultural-engineering departments insist that the extension agricultural engineers shall have the same general training as the research engineers, shall be included in all research conferences, and shall at all times be available for consultation to insure ultimate practicability in the results of the research so far as possible.

CLASSIFICATION OF RESEARCH

Once the necessity for the solution of a problem in agricultural engineering has been established and the identity and specific character of the problem are known, the logical procedure would appear to be the proper classification of treatment which the problem justifies.

The recent research conference appears to have classified fact-finding procedures in agricultural engineering into surveys and general investigations, comparative testing, experimental development and adaptation, and fundamental research.

The agricultural-engineering research program of the past has been replete with surveys, general investigations, and comparative testing. It seems likely that almost everything of an engineering character in agriculture under the sun has been surveyed and generally investigated. This was necessary when the subject was new and the field of its application relatively unknown and unexplored. Surveys and general investigations clarified the fields of research in agricultural engineering and provided a background of information as to the general character of the problems involved and how they contacted with agriculture. The information obtained also was useful in attracting the attention of research administrators and in convincing them of the vast economic importance of this field of research.

It probably is true that more surveys and general investigations are needed to further clarify some of the less well-known fields of engineering in agriculture. It seems likely, however, that with the background of information already available the logical future development of research in the better known branches of agricultural engineering will be along lines of the fundamental solution of important basic problems and the experimental development and adaptation of engineering methods and equipment.

Application of engineering principles to agricultural problems of a biological character is complicated by many involved variable factors and demands close contact with the agricultural sciences concerned

For example, the mechanics of tillage involving the expenditure of power as draft and the economical production of desired tilth conditions in soils still involves many unknown features and unsolved problems. The whole question of the logical adaptation of available tillage tools to conditions where they will be most useful is tied up in the mechanics of tillage. The fundamental reasons for wear in tillage tools also are relatively unknown, and until they are explained by fundamental research in soil dynamics, the control of such wear is a matter of speculation only. The efficient and economical adaptation of the traction elements of draft machinery also is dependent largely upon an understanding and ability to control the dynamic properties of soil. Since power and labor expenditures in draft and tillage are such large items in the cost of production, it seems likely that future research will be aimed largely at gaining a precise control of the soil factors involved.

It appears, therefore, that the experimental development and adaptation of equipment will in the future involve a greater manipulation and application of fundamental principles. For example, a striking trend in this work is the analytical expression and measurement of stresses in wheels used in agricultural machinery. This precise method of experimental development is resulting in greater strength and economy in wheels and naturally is beneficial to both the manufacturer and user of farm machinery.

RESEARCH PROCEDURE

Having a specific problem, the solution of which is to serve a definite purpose in agriculture, and having decided upon the type of treatment required in the solution of the problem to attain the objective, it seems likely that the research worker in agricultural engineering of the future will want to follow an appropriate procedure.

The Committee on Experiment Station Organization and Policy of the Association of Land-Grant Colleges and Universities suggests that the procedure should be up to date, representing the progress and current views on methods and technique. It should give data that will stand statistical analysis and will be comparable with other similar accepted data.

In this connection it is significant that agricultural engineering consists largely of the application of engineering principles to biological problems and as such is likely to involve several variables. To state the case more plainly, it is extremely difficult in agricultural-engineering research to hold all but one factor constant at a time. This is true particularly in studies relating to the mechanics of soil, the so-called physiological mechanics of plants and the like. This suggests the desirability of including statistical analyses of the data as a necessary part of the procedure of research

in agricultural engineering in order to throw the significant relations between important factors into relief.

The biological character of the agricultural problems, to which engineering principles are to be applied, also emphasizes the importance of close contact with the agricultural sciences involved. For example, the curing of hay by mechanical methods has long been done without much consideration for the principles of plant physiology involved. Studies by plant physiologists have shown, however, that by taking full account of the physiological reactions of the cut hay plant, the natural curing of hay may be greatly accelerated. This is important under any circumstances from the standpoint of the labor saved, but is particularly important in very humid localities where hay losses through spoilage and rainy weather are excessive.

This implies, therefore, that the procedure of agricultural-engineering research should consider fully the agricultural features involved. Close coordination with agriculture would seem essential as a guide to proper procedure, not only in the establishment of basic requirements to be met, but in indicating how engineering principles can be applied most effectively in meeting these requirements. For example, it was possible to cure Johnson grass hay under humid conditions in two or three days with good weather conditions by use of ordinary mechanical methods. But by taking into account also the physiological reactions of the hay plant it was possible to cure this hay in one day, thereby saving labor and preventing spoilage.

The procedure also should provide for a thorough and reasonably complete investigation of the concrete limited problem under study and should avoid fragmentary and superficial ramifications. This implies adherence in the procedure to the carrying through to completion of the one main line of thought which expresses the problem. It also provides more or less automatically for a time limitation in the respect that when the main problem is solved the research involved is complete. It also permits definite and adequate financing of the undertaking. This leads to the relations which the research agricultural engineer must have with the director of the research institution with which he is connected.

ADMINISTRATIVE FEATURES IN RESEARCH

The project of research in agricultural engineering must be organized from the standpoint of the administrative regulations of the experiment station or other research institution wherein it will be carried on. The research administrator is a referee and a financier. He may know the requirements of agriculture in general, but he may not be an agricultural engineer. As a referee he must be convinced that the undertaking is worth while to the agriculture of the state, and that it is a concrete affair of limited duration, which can be financed reasonably.

The Committee on Experiment Station Organization and Policy of the Association of Land-Grant Colleges and Universities has concluded that, while the project outline is not a thing to be standardized, it may properly be expected to conform to certain essentials which experience and good usage have disclosed. The minimum of such essentials for an acceptable project outline have been stated by the Committee, in brief, as follows:

1. A clear-cut, specific title, accurately characterizing the work to be undertaken
2. A statement of the leaders and the cooperative features
3. Clearly defined objectives
4. An explicit statement of the procedure to be followed
5. An indication of familiarity with the present status of the subject as indicated by a summarized statement of the work of others, if any
6. An estimate of the funds required to carry the study through to completion.

While the precise and complete form and content of a project outline applicable to all cases would be difficult to prescribe, adequate and definite information on all the points enumerated above is considered essential in passing judgment on projects submitted to research administrators for approval. This is particularly true where research apparatus is desired. It is enough in this connection to quote from C F Kettering, "The research problem is not solved with apparatus; it is solved in a man's head. No one ever solved anything in a research laboratory. The research laboratory is the means by which, when a man has an idea clarified in his head, it is possible to do the solving of it."

COORDINATION AND COOPERATION

The desirability of coordination of the engineering with the agriculture within a research institution in the conduct of agricultural-engineering research has been pointed out in the discussion of procedure. The logical future development of research in this subject would seem, however, to call for coordination of such work regionally and nationally as well. The necessity for the elimination of unnecessary duplication of effort is an important economic consideration especially at this time. More important in the long run are the benefits resulting from a community of thought on a single regional problem.

For example, the exchange of thought and ideas on the solution of the engineering problems of cotton planting in the cotton belt or the harvesting of corn in the corn belt may hasten their solution immeasurably and insure wide practical applicability of the results.

Cooperation between local, regional, and national research agencies also has its place and probably finds its greatest usefulness in the frequent greater ability of federal agencies to solve a problem regionally or nationally in its fundamental aspects, permitting local agencies to adapt the findings to local conditions and practices.

The tendency is toward more intelligent and widespread coordination of research activities both public and private, and this in turn is tending to define the fields of these two agencies more clearly. In short, the public service research engineer is confining his endeavors to the establishment of fundamental principles and requirements as a basis for equipment adaptation and as a guide to the designer of new equipment. The private research engineer is tending to confine his activities to studies of materials and the principles of engineering design which will meet the requirements laid down by the agricultural engineer in public service, as well as the requirements of economical and profitable mass production. The logical coordination of these two seems absolutely essential if research in agricultural engineering is to render maximum service to agriculture, and it seems likely that the future development of this work will be along such lines.

CONCLUSIONS

The indications are that the future research in agricultural engineering will be confined largely to attempts at the permanent fundamental solution of specific problems which represent limiting factors in different important agricultural practices. In the words of C. F. Kettering, "Let's find out what the limiting factor is. Then when we get all that down, it isn't going to be any great big complicated problem. It is going to be a simple problem, which can be allocated to some definite line of research."

The indications also are that the future research in agricultural engineering will be a highly coordinated undertaking. There will be cooperation locally between the engineers and the commodity groups of agricultural scientists. There will be regional cooperation between experiment stations resulting in that highly desirable exchange of thoughts and ideas and community of interest in common problems with the attendant elimination of duplication of effort and the consequent acceleration of results and economy in the use of research finances. There will be cooperation between local and regional bodies and national bodies in the study of problems, the fundamental solution of which may not be possible without national aid. There also will be that coordination of public and private research so essential to complete the cycle of 100 per cent engineering service to agriculture.

Temperature Gradient in Milk Cooled by Direct Immersion[1]

By Raymond G Bressler Jr[2] and John E Nicholas[3]

THE two most general methods of milk cooling now practiced on the farm, especially where mechanical refrigeration is employed, are aeration and direct immersion. Each method is dependable, effective, and satisfactory under certain conditions.

It has been asserted that the aeration method is the more desirable because milk can be cooled more rapidly than by direct immersion. The approximate time of cooling 10 gal of milk over a small, horizontal, closely-fitted, tubular aerator is 6 min. This type of equipment would cool 30 gal in 18 min. The time to prepare for and to clean up after the cooling operation is not taken into account.

In order to establish as accurately as possible the rate of cooling in a direct-immersed 10-gal can it was necessary to measure the temperature of the milk at different depths in the can and obtain the temperature readings at short intervals, preferably 5 min apart, or at least 12 readings per hour. A 50 mv potentiometer with a sensitive galvanometer and thermocouples made of No 30 wire assured rapid readings of temperature with accuracy to ½ deg (Fahrenheit).

Eleven thermocouples spaced 2 in apart were mounted on a self-balanced stand. When placed on the vertical axis of the can the top couple was at the surface of the milk and the lower couple touched the bottom of the can. This arrangement proved satisfactory.

When these tests were conducted it was discovered that a temperature gradient develops in the milk when cooled by direct immersion. The temperature gradient is the difference in temperature of the milk per unit depth in the can. In the case under consideration, the temperature gradient in the milk is the change in temperature $d\theta$, along the center axis, from the surface of the milk down toward the bottom of the can. If the change of depth is dx, then the temperature gradient, at any instant after the cooling starts, is expressed by $d\theta \div dx$.

Where the temperature gradient is large, the milk is not cooled uniformly. It is desirable, undoubtedly, that the milk cool as uniformly as possible. Several tests were made to determine what factors most affect the temperature gradient.

Milk was cooled with a comparatively small quantity of cooling water which was not agitated; with a similar small quantity agitated during the cooling process; and with a comparatively large quantity of cooling water which was not agitated during the cooling process. The results of the three tests are shown in Figs. 1, 2, and 3.

The refrigerating unit was a small, farm type, 1/6-ton machine, with an air-cooled condenser. The evaporating or cooling coils were suspended in the geometric center of the cooling water of the tank. Inside dimensions of the milk-cooling tank were 3 ft by 6 ft by 28 in deep. Its inside and outside walls were made of 3 and 4-in concrete, respectively, with 3 in of cork insulation between the walls. For agitation of the cooling water, a small 3-bladed propellor direct connected through a telescopic shaft to a fractional horsepower electric motor proved satisfactory. The ratio of the quantity of cooling water used to the quantity of milk cooled is designated by R, and will be referred to merely as "ratio."

Fig. 1 shows the milk cooling rate in a 10-gal can. The eleven curves shows the temperature of the milk, in the same can, at any time, for every 2 in, from the top of the milk to the bottom down through the center of the can. The cooling process was without agitation of the water, which was initially at 36 deg (Fahrenheit), and the ratio, $R = 5$.

The temperature gradient $(d\theta \div dx)$ measures the change in temperature $(d\theta = \theta_1 - \theta_2)$ per unit of depth ($dx = 1$ in) along the center axis of the can. In the example taken, $\theta_1 = 62.5$ deg and $\theta_2 = 43.8$ deg. The change in temperature $(18.7 \div 18)$ gives the temperature gradient $(d\theta \div dx)_1 = 1.038$. Similarly $(d\theta \div dx)_2$, $(d\theta \div dx)_3$ and $(d\theta \div dx)_4$ for the second, third, and fourth intervals is 0.878, 0.795, and 0.745, respectively.

Fig. 2 shows the effect of agitation of the water on milk cooling rate and temperature gradient when the same ratio as before ($R = 5$) was used, but the initial temper-

SYMBOLS

$d\theta$ = change in temperature

dx = change in depth

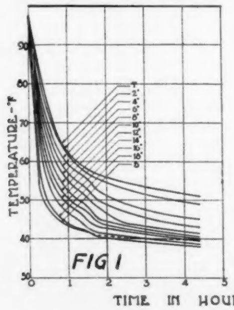
R = ratio of quantity of cooling water used to the quantity of milk cooled

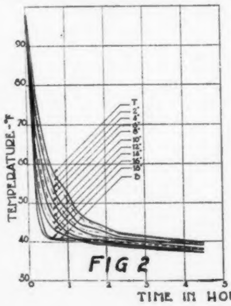
[1] Paper presented at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

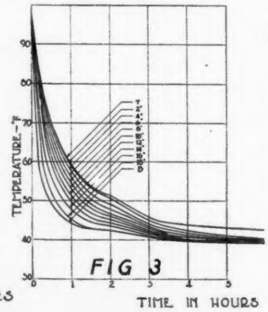
[2] Student in agricultural engineering, Pennsylvania State College. Student A S A E.

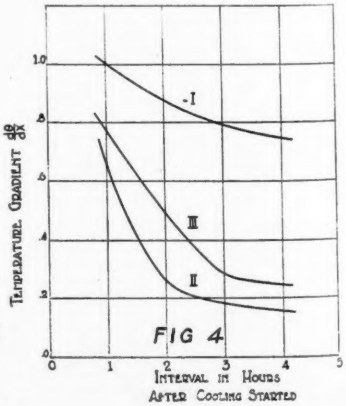
[3] Associate professor of agricultural engineering, Pennsylvania State College. Mem A S A E.

Temperature gradients in milk cooled in 10-gal cans by direct immersion in water in an insulated concrete tank. Figs. 1, 2, and 3 show time-temperature relationships for every 2 in from top of milk down through the center of the can. Fig. 1 shows results of cooling without agitation in 36-deg water with $R = 5$. Fig 2 shows influence of cooling with agitation in 33-deg water with $R = 5$. Fig 3 shows the effect of a higher ratio, $R = 23$, in cooling without agitation in 36-deg water. Fig 4 is a comparison of the temperature gradients shown in Figs. 1, 2 and 3









ature of the cooling water was 3 deg lower. The temperature gradient ($d\theta \div dx$) under these conditions at the above corresponding intervals is 0.666, 0.2665, 0.1885, and 0.1610.

Fig. 3 shows the effect of a large ratio ($R = 23$) on the rate of cooling and temperature gradient. There was no agitation of the cooling water which was initially at the same temperature as that shown in Fig. 1.

The curves I, II, and III in Fig. 4 show the temperature gradients obtained from Figs. 1, 2, and 3 at the same corresponding intervals.

Curve II shows the distinct advantage of agitation of the relatively cold cooling water. Curve III shows the advantage of a relatively large ratio, R, when no agitation is employed. With no agitation and small ratio, the temperature gradient is large and milk cools slowly and nonuniformly as shown by Curve I.

SUMMARY

1. Milk may be cooled as rapidly by direct immersion as by aeration.
2. By direct immersion all of the milk produced begins to cool at the same time.
3. Direct immersion is recommended in all cases for small dairy farms unless the milk is bottled on the farm.
4. By direct immersion milk can be cooled to below 50 deg in 30 min if the cooling water is less than 36 deg and R is greater than 8. Water should be agitated.
5. A temperature gradient exists when milk is cooled by direct immersion.
6. The temperature gradient will be a minimum if low temperature cooling water is used. A temperature of 33 to 36 deg is recommended. The lower limit is to be used if uniformity and rapidity in milk cooling is desired.
7. A large quantity of cooling water is desirable for rapid cooling of the milk if no agitation is employed.
8. The value for ratio, R should be 8, 12, and 16 for 33, 36, and 40-deg cooling water, respectively, without agitation.

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The Operation of Farm Machinery Over Terraced Land[1]

By C E Ramser[2]

ONE OF THE OUTSTANDING problems in the practice of terracing is the satisfactory operation of farm machinery over terraced land. It is somewhat complicated by the great variety of machinery used in the various farm operations, and by the several types of terraces with differing machinery requirements. Also different degrees of land slopes play an important part in adding to the intricacies of this problem. Again requirements of machinery vary greatly depending upon whether the rows are conducted parallel to or across the terraces at any angle.

The logical method of attacking this problem consists of first deciding, as nearly as possible, upon the most satisfactory cross-section of a terrace from the standpoint of economy in construction, facility of machinery operation, and adequate erosion control for any particular section of the country or for lands of different slope in the same section. On lands of minimum slope, wide terraces constitute the most satisfactory solution of the machinery problem; on lands of moderate slope, the width of terrace is limited to a certain extent by the increasing cost of construction; and on steep slopes it is practically impossible, regardless of cost, to build a terrace wide enough to meet satisfactorily the requirements of all existing farm machinery.

In regions where the use of single-row horse-drawn machinery is economically sound and is expected to continue, the machinery problem is negligible provided farming operations are conducted parallel to the terraces, which is generally the prevailing practice.

In regions where two-row tractor-drawn machinery predominates or is rapidly supplanting the one-row equipment, the machinery problem is perhaps the most acute at the present time. On the more moderate slopes the crossing of terraces with machinery is quite commonly practiced, while on the steeper slopes the farm operations are generally conducted parallel to the terraces although some farmers adhere to the same practice in laying out rows regardless of slope. If all farmers would adopt the method of running rows parallel to the terraces, the machinery problem would be greatly simplified.

In regions where large machinery such as the combine is in general use and where wheat is the principal crop grown, there has not as yet been a very general adoption of the practice of terracing, and in the few localities where terracing has been practiced there seems to be a decided prejudice in the minds of the farmers against the system of following the terraces in farming operations.

Considerable experience has been gained from observations of the operation of machinery over terraced land on the several soil-erosion experiment farms established by the U. S. Department of Agriculture. Many difficulties have been encountered. These will be described briefly together with some suggested remedies in the hope of stimulating a general discussion of a constructive nature.

Tractors. Tractors of the tracklaying and wheel types were used in general farm operations such as plowing, disking, and harrowing on the various soil-erosion farms. It was found from the standpoint of traction particularly in crossing the comparatively loose soil in the tops of the terraces that the tracklaying tractor had no appreciable difficulty, while the wheel tractor could not readily cross the terraces with the same load that it could easily handle between the terraces, and much time was lost due to digging in and stalling in crossing a terrace. This applies particularly to newly built terraces. About the only disadvantage of the tracklaying tractor is the shock received by the tractor and operator when the tractor moves up one side of a terrace and drops down on the other. This holds true whether crossing the terrace at right angles or at any other angle. The shock to the tractor can be greatly minimized by building terraces having a comparatively flat top several feet wide. This tracklaying tractor is also superior to the wheel type when operating parallel to and on the side slope of a terrace, since there is practically no tendency to creep or slip down the slope as is the case with the wheel tractors. The operation of the wheel

[1]Paper presented at a meeting of the Land Reclamation Division of the American Society of Agricultural Engineers, at Chicago, December 1931.

[2]Senior drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Guthrie. Oka. Mem A S A E.


(Left) Drilling across a terrace at an angle results in planting too deep on top of the terrace and too shallow in the channel. (Right) A flexible hitch for drawing several sections of harrow in operating parallel to or at angles of less than 90 deg to terraces

tractor can be improved by the use of rims and lugs adapted to the soil conditions and often by a redesign of the steering mechanism to permit making shorter turns.

Plows and Listers. The two-bottom plow has a distinct advantage over the single-bottom plow when operating on the side of a terrace embankment, since there is a greater tendency for the single-bottom plow to slip sidewise down the slope. On the federal farm at Pullman, Washington, where the slopes of the terraced land vary from 15 to 40 per cent, it was found necessary to conduct all plowing operations parallel to the terraces. On slopes of less than 25 per cent the soil could be thrown to the center of the terrace from both sides, but on steeper slopes it was necessary to turn the soil down hill only, and return trips were made where possible on flatter slopes or by circling the hill. Under such conditions a reversible plow could be used to advantage. Another solution would be an implement that would stir the ground thoroughly without turning it over.

On the farm at Hays, Kansas, most of the land has slopes varying from ½ to 4 per cent, and all farming operations on this land are conducted in straight lines without regard to the terraces. The one-way plow was used on this land and the tops of the terraces were torn down considerably requiring much work to maintain their height. Where the one-way plow was operated parallel to the terraces on the steeper land, it served to maintain the height and no other maintenance work was required.

Also a six-row lister consisting of three independent gang listers in one frame was used across the terraces. Practically no trouble was experienced in crossing terraces with base widths of 30 to 40 ft and a height of 12 to 18 in. However, single independent listers with free vertical movement would follow the surface of the ground better in crossing terraces but should be dependent on the balance of the units for horizontal movement. The effect of the lister was to reduce the effective height of the terraces. A three-row tractor lister was used on slopes greater than 4 per cent and was thrown out of the ground when crossing a terrace so as to prevent reducing the height of the terrace.

Planters and Drills. Single-row cotton and corn planters cause very little trouble in farming terraced land when operated either parallel to or across terraces. When one-row machinery is used, a row is generally planted on the top of the terrace, and for two-row machinery the usual practice is to plant one row on each side of the top. In operating parallel to terraces with the two-row tractor planter there is a tendency for the planter to creep down the slope so that the covering device does not follow the furrow opener, due to the slight angle with the terrace at which it is necessary to drive the tractor in order to balance the creeping effect. If the planter were made sufficiently flexible, possibly by means of a hinge in the center, the two rows, one on each side of the top of the terrace, could be planted in one operation and there would be no necessity for operating the planter on the steepest part of the side slope of the terrace. In planting rows across a terrace there is a tendency to plant too deep on the top of the terrace and too shallow in the channel. This could be overcome by means of a gage wheel of sufficient width and diameter to maintain a uniform depth of each furrow opener in loose compact soil.

Observations tend to show that, except on very wide terraces, wide drills, unless they can be made much more flexible in operation, are not adapted for use particularly where terraces are crossed at any angle and on the steeper slopes. Where a drill is operated parallel to a terrace and the width of the drill is less than the side slope of the terrace no appreciable difficulty is encountered. Where the terrace is too narrow to accommodate the full width of the drill, it is practically impossible to drill seed in the terrace channel to the desired depth. In drilling across terraces at any angle the chief difficulty consists of a lack of flexibility which results in planting the seed at different depths, too deep on top of the terrace and too shallow in the terrace channel.

Considerable difficulty with the press wheel type of drill was encountered on the Hays project where the covering disks are located between the truck and the press wheels which gives a three-point contact with the ground surface. When the surface is low between the truck and press wheels, the disks do not penetrate the ground resulting in shallow seeding, and deep seeding occurs when the surface of the ground is high as at the top of a terrace. Placing the press wheels nearer the disks and the use of side wheels to carry the weight would largely remove this difficulty. The ordinary drill with the side wheels in line with the disks can cross terraces better than the press-wheel type drill. Where the practice of crossing terraces is followed, much better results are accomplished where the drilling is done at right angles to the terrace.

Cultivators. The operation of the general-purpose tractor has been attracting considerable attention particularly in the cultivation of crops. Two outstanding criticisms are the lack of self-stabilization which results in a tendency to creep when working on the side of a terrace and covering or plowing out the crop, and lack of flexibility which is responsible for the shovels digging in excessively deep when crossing a terrace, often plowing out the crop row and damaging the terrace. Less digging in occurs where the location of the cultivator gangs is such that they rise and fall with the wheels of the tractor in crossing a terrace. It seems that depth of plowing might be satisfactorily regulated by the use of gage wheels at each gang of sufficient size and width to lift the gangs in loose soil conditions. As suggested for the two-row tractor corn planter, if the cultivator could be made flexible enough to cultivate the two rows one on each side of the top of the terrace in one operation, there would be no necessity for operating the cultivator on the steepest part of the side slope of the terrace.

In cultivating curved rows on terraced fields the driver's attention is almost continuously required in steering the tractor. It seems that, if a power-lift were provided with all equipment furnished with a general-purpose tractor, it would greatly facilitate the combined work of steering the tractor and operating the cultivator gangs.

Harrows, Disks, and Rollers. Harrows, disks, and rollers operate better on terraced land when built in narrow sections. Flexibility in the section of a harrow is important for satisfactory operation over terraces. With the ordinary hitch the harrow works best when operated at about right angles to the terraces.

An 8-ft soil packer was used on the federal soil erosion farm near Bethany, Missouri, on terraces about 20 ft wide. It worked fairly well at right angles to the terraces, but was unsatisfactory when operating either parallel to or at angles less than 90 deg to the terrace. Greater flexibility is needed by building the machine in small sections, each section being free to move vertically independent of the other sections.

Lack of sufficient flexibility is also a criticism of the tandem disk particularly in crossing terraces at an angle. The tandem disk operates better either at right angles or parallel to the terrace.

Mowers, Binders, and Rakes. Not much trouble has been experienced in the operation of mowers over terraced land. However, the consensus of opinion on the different farms is to operate the mower parallel to the terraces for the best results. In crossing terraces at any angle there is a tendency to leave high stubble in the terrace channels and to miss the grain if it is unduly short. Naturally the best results are obtained with a short cutter bar on a wide terrace. In purchasing a mower or binder for any particular farm, the length of the cutter bar should be chosen to conform to the width of the terraces. In crossing terraces at right angles some slight changes might be advisable to prevent the pitman from running into the ground at the top of the terrace.

There is a tendency for the heavier machines such as the grain and corn binder to creep down the side of a terrace embankment. This slipping caused more trouble in the case of the corn binder than the grain binder, owing to the fact that the former must follow the rows. This tendency to slip could no doubt be greatly reduced by properly designed wheels. Some suggestions for improving the flexibility of the binder are (1) attaching the cutting table to the remainder of the machine by a flexible connection so as to permit the machine to more nearly conform to the shape of the terrace; (2) providing for the elevating or lowering of the outside end of the platform, and (3) devising a method of tilting the machine forward and backward to a greater extent than can be done on the present machine to facilitate crossing terraces.

Hay rakes operate quite satisfactorily parallel to terraces but are not flexible enough in operation to cross terraces successfully. Push rakes are especially lacking in flexibility. Better results are obtained with all hay equipment such as rakes, tedders, and hayloaders when operated parallel to the terraces.

Combines. Observations have been made on the operation of combines over terraced land on the experimental farms at Pullman, Washington, and at Hays, Kansas, where the land slopes are excessively steep and comparatively flat, respectively. On the Hays farm it was found that a 20-ft combine would work successfully over terraces 30 to 40 ft wide and on slopes varying from level to 4 per cent, provided that the necessary flexibility was obtained by the platform working independent of the separator.

Actual measurements showed that the maximum height of the grain stubble was from 10 to 18 in and seldom was any grain left standing in the field. This does not apply however to combines with platform rigidly attached to the separator. A combine with pick-up attachment operated very well parallel to the terraces but unsuccessfully in crossing terraces for the reason that the pick-up attachment was rigidly fastened to the combine platform. Greater flexibility could be secured by building the attachment independent of the combine platform similar to the manner in which the combine platform and separator are built as independent units.

In the Palouse region near Pullman, Washington, the combines in use are of the leveling type for operation on the steep slopes. They have two rear wheels and a single front wheel and can cross a terrace at any angle provided the terrace ridge does not touch the frame of the machine. Ordinarily this occurs on slopes greater than 25 per cent when operating perpendicular to the terrace. Wheat 3 or 4 ft high on slopes of 15 to 20 per cent can be successfully harvested by operating the combine without regard to the terraces. On steeper slopes or short crops it was found that the combine should be operated parallel to the terraces. It is believed that, if the cutter bar on the combines were reduced in length to about 6 or 8 ft, which is about one-half the standard length of the bars now in common use, a great improvement would be made in the performance of the combine in harvesting grain on steep slopes.

Before closing this discussion attention is directed to the fact that terracing often improves fields for the smoother operation of farm machinery. Gullied fields are a source of great annoyance to the farmer in the movement of farm machinery and often they are necessarily farmed in sections between the gullies that cannot be crossed with machinery or only at the risk of serious damage to the machines.

Objection to the somewhat faulty operation of present machinery in terraced fields is no doubt responsible to some extent for the decided reluctance of many farmers in adopting the practice of terracing. A study of the situation leads one to believe that the difficulties encountered are unduly magnified in the minds of these farmers. It is believed that this discussion demonstrates that the difficulties are by no means sufficient to discourage a farmer from terracing his land and that they can easily be remedied in most instances with simple and inexpensive alterations or improvements in machinery design, or slight modifications in the cross-section of terraces, or changes in the method of conducting farm operations on terraced land.


(Left) Operating a harrow parallel to a terrace on a 40 per cent slope. (Right) The roller wheels of this cultipacker fail to touch the ground in the terrace channel when it is operated on and parallel to the terrace

Engineers and the Control of Erosion[1]

By Lewis A Jones[2]

THE control of soil erosion is the most important problem that faces American agriculture today. It is more important than farm credit, marketing, farm relief, or any of the other problems we hear so much about during these times of economic stress. It is a problem that strikes at the fundamental resource of the land—the fertile top soil—and unless controlled will ultimately, and at no distant date, render large areas of cultivated land in the United States valueless for agricultural uses. In fact, millions of acres of what was once fertile farm land have already been eroded beyond repair.

The furnishing of credit and markets may tide the farmer over and enable him to survive temporarily, but unless his fundamental asset is conserved, he is certain to fail ultimately. His failure will be a loss not only to himself and his family but also to posterity.

Erosion is caused chiefly by the rapid movement of rain water down slopes of the land surface. To control and prevent excessive erosion it is necessary to control the flow of the run-off water so that it cannot attain the velocity necessary to erode the soil over which it travels. Nature controls erosion largely by supplying a vegetable covering that slows up the rate of run-off and results in a large part of the rainfall being absorbed by the soil. It is not until man, by artificial operations such as cultivation, overgrazing with livestock, lumbering activities, fires, etc., destroys the balance established by nature that excessive run-off and resulting soil erosion become a serious problem. If rolling land is to be used by man to obtain food and shelter, it is necessary that some means be developed to control the increased run-off and soil erosion which follow his activities.

Recognition of this fact is by no means a modern discovery. From their attempts to control erosion by the construction of bench terraces, it is evident that the ancients of Asia and Europe were aware of the serious soil losses which resulted from cultivating steep slopes. In China where people cleared the uplands and made no provision to protect the cultivated slopes, they were forced eventually to abandon the eroded uplands and migrate to the bottom land areas. This caused overpopulation of the valleys and as a result food famines were quite common.

Recent data relating to the ancient Mayan civilization of Central America indicates that possibly the primary reason for the abandonment of the region which they inhabited was uncontrolled erosion, erosion resulting from the cultivation of the hill land without proper protection. The fertility of the hill land was destroyed, and the soil which washed from the hills filled in the stream channels in the valleys causing the formation of disease-ridden swamps that finally forced the inhabitants to abandon the region.

We in the United States are prone to think of ourselves as a superior people, above committing errors such as are evidenced in past history and in older countries; yet I venture the assertion that in all history there has never been a people so extravagant and thoughtless in the use of agricultural land.

Eighteen principal soil regions or soil types in the United States, in which erosion is considered a serious menace to agriculture, have been outlined by the U.S.D.A. Bureau of Chemistry and Soils. These regions include areas in 35 of the 48 states and give some idea as to the widespread distribution of excessive soil erosion. That Bureau estimates that at least 75 per cent of the cultivated land in the United States is affected seriously by erosion and that over 17,000,000 acres of formerly cultivated land have already been destroyed.

At the present time we hear a great deal about land utilization, marginal land, and submarginal land. Undoubtedly there are extensive areas of land now being cultivated upon which it is impossible to grow crops profitably in competition with the world markets. Much of this land has become marginal through excessive erosion. Large additional areas upon which good crops are now being raised will have to be included in the area of submarginal land unless steps are taken promptly to control erosion.

Erosion occurs in two forms, sheet washing and gullying. The latter generally is the more dreaded because its destructive effects are more obvious. Where erosion is unchecked, deep gullies invariably develop in the fields. Their formation causes not only absolute loss of land and inconvenience in tillage, but also a marked lowering of the water table of adjoining land, the soil of which is then unable to retain the proper moisture content for production of crops and for withstanding periods of drought.

The loss by sheet washing, or sheet erosion, is generally underestimated and is regarded by many farmers as of no particular consequence. The chief danger from sheet erosion lies in its insidiousness. It is this type that slowly, almost imperceptibly, carries away the fertile top soil, so gradually that only through diminishing crop yields does the farmer become aware that remedial measures are imperative to save his farm. Many are caught as was the farmer in northeastern Nebraska who wrote to his college of agriculture asking why the soil in many places on his farm was turning from black to brown. He stated that the brown spots did not yield as good crops as they had before the color changed. He was advised that his soil was not changing color but was eroding away and that the brown spots were areas of subsoil from which the fertile black top soil had washed off. The farmer was loath to believe the explanation, stating that his land was not steep, but only slightly rolling, and that there were no signs of gullies on his place. Difficulty is often encountered in convincing landowners that destructive sheet erosion is taking place on their farms.

Where does the agricultural engineer fit into this picture of soil erosion? I like to think of him as the doctor diagnosing the disease, determining the cause of the trouble and developing remedies that will control, not the disease directly, but rather the cause of the disease. There is to my mind a striking parallel between the control of erosion and the control of malaria, that scourge that has caused so much suffering and loss in this country. For years doctors worked on the patients trying to perfect a cure but made little headway. It was not until they determined the cause of the disease, the Anopheles mosquito, and took steps to control that mosquito, that malaria was checked.

The engineer, in studying the problems of soil erosion and its control, is interested in the disease, soil erosion, but he is more interested in determining the cause of the disease and in developing remedies that will control the cause and thus prevent the disease.

Erosion is caused chiefly by the rapid movement of rainfall down the slopes of the land surface. It is this run-off water that causes the disease. Erosion is more pronounced on steep slopes than on gentle because the run-off water attains higher velocities and therefore can transport more soil.

To control erosion it is necessary to prevent the run-off water from attaining sufficient velocity to carry away

[1]Paper presented at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Chief, division of drainage and erosion control, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem A S A E.

the soil particles, or to protect the surface of the soil against the action of the water. In most localities nature protects the land surface against run-off water by a heavy vegetative covering. When man cultivates the land, especially in row crops, he destroys the vegetative protection against the run-off that is supplied by nature and must furnish a substitute if trouble is to be avoided.

It is presumed that man must continue to cultivate the land, and that he desires to grow his most profitable crops, taking into consideration, of course, the proper maintenance of the fertility of the soil. Therefore, he must have some method of controlling the velocity of the run-off water from his land. Thus erosion control develops primarily into a problem in hydraulics, the control of the flow of water, a science which the engineer is trained to apply. It develops into a question of hillside drainage, the construction of drainage channels on hillsides in such manner that they will collect the run-off water and conduct it from the hillside to a suitable outlet before it attains sufficient velocity to erode the soil. This method of hillside drainage as developed by the engineer is commonly known as "terracing."

The drainage channels are formed by throwing up ridges of soil called "terraces" to prevent the rapid flow of water down the slope. Such a terrace is constructed near the top of a hillside, and additional terraces are constructed at intervals down the slope. The vertical distance between terraces depends upon the slope of the land and the character of the soil. By giving each terrace a slope, the water that gathers in the drainage channel back of the terrace is conducted along the terrace to the outlet ditch, which is usually located along the edge of the field, and so constructed as to be protected against erosion. Unless these outlets are properly protected they are likely to become gullies. Properly constructed terraces are low, broad ridges of soil that do not interfere with cultivation. Farm machinery can be operated over them, and the terraces can be planted to crops.

The efficiency of terracing in controlling erosion is evidenced by the rapidity with which the practice is being adopted by farmers throughout the country. More than 3,000,000 a were terraced in 1931, and the practice is spreading rapidly as the need for controlling erosion becomes more generally realized. Many millions of acres are at present successfully terraced and a farmer need not hesitate to follow the terracing practices recommended by his state agricultural college.

Results obtained on the various soil-erosion experiment stations that have been established during the past few years, justify the confidence that has been placed in such work. On the experiment farm at Guthrie, Oklahoma, a loss of 43.9 tons of soil per acre occurred during 1931 from an unterraced area planted to a cover crop of rye, followed by cow peas, and later by winter wheat; while on a similar terraced area planted to the same crops only 1.25 tons of soil were lost per acre; 35 times as much soil was eroded from the unterraced as from the terraced area. On the farm at Bethany, Missouri, which is located in an area where erosion is especially serious, unterraced land with an 8 per cent slope planted to corn lost by erosion approximately 104 tons of soil per acre. The average loss of soil on five terraced areas of the same slope and planted to the same crop was only 2.89 tons per acre. Think of it! More than 36 times as much soil was lost from the unterraced area as was lost from the terraced land. In other words, the terraced land could grow 36 crops of corn, and the soil loss from erosion would only equal that lost from one crop on unterraced land. Such data must convince even the most skeptical as to the efficacy of terraces in erosion control.

Two of the federal farm loan banks realize the effectiveness of terraces in erosion control. They require that all rolling land upon which they make loans be terraced. One, The Federal Farm Loan Bank of Houston (Texas) employs an engineer to check the farms upon which they have loans to see that all terraces are properly constructed and maintained.

Insurance companies are beginning to realize that long-time loans cannot safely be made on farms that are washing away. During the past two years three of the large companies have employed agricultural engineers to direct the work of controlling erosion on farms they have had to take over. These companies are now refusing to make loans on unterraced farms.

The federal department of agriculture is awake to the seriousness of erosion over a large part of the United States, and during the past three years has had appropriations by Congress for making studies of the problems involved. For this fiscal year the appropriation amounts to $280,000.

This money is being expended on investigations relating to all phases of soil erosion and its control. The U.S.D.A. Bureau of Chemistry and Soils is conducting investigations covering the physical and chemical properties of soil as they relate to erosion. It is also studying the effectiveness of crop rotations and the adding of humus to the soil to reduce erosion losses.

The U.S.D.A. Forest Service is studying the effect of herbaceous covering in controlling erosion on the range lands of the West and the effect of forests on run-off and erosion control.

The U.S.D.A. Bureau of Agricultural Engineering is investigating the engineering problems relating to the design and construction of satisfactory erosion control works, such as terraces and soil-saving dams, the development of more efficient machinery for constructing terraces, and the requirements of farm machinery for operation over terraced land.

Some of the questions to which engineers are now seeking the answers include the following: Are present practices the most economical that can be developed? Can the same results be obtained with terraces spaced farther apart or with smaller terrace embankments, thus reducing the cost of terracing? Are terraces, in some instances where the grades are steep, carrying off too much soil from the field, or where the grades are level is an effort being made to conserve all of the soil at too great cost, resulting from the closer spacing of the terraces? Cannot improvements be made in present terracing machinery, or new machinery be developed that will reduce the cost of


(Left) Water held by a level terrace on oat land, at the Guthrie, Oklahoma, Experiment Station. (Right) Terraces with variable grades and spacings on land with a 10 per cent slope

construction? Can the cost of farming terraced land be reduced by making changes in the cross-sectional design of terraces or by improvements in farming methods and in farm machinery?

Work at the soil erosion farms has developed the fact that much of the farm machinery now on the market is not sufficiently flexible to operate efficiently over terraced land. In many instances only slight changes in design are necessary to increase the flexibility sufficiently to meet terrace conditions. Attention has been called already to the fact that 75 per cent of our cultivated land is suffering from erosion and ultimately a large percentage is certain to be terraced. It would seem good business for the manufacturers to take steps to increase the flexibility of their machinery to meet terraced conditions.

In closing I would like to read a short verse of unknown origin which recently came to my attention; it is entitled "Hordes of Gullies:"

Hordes of gullies now remind us
We should build our lands to stay;
And departing leave behind us
Fields that have not washed away.
When our boys assume the mortgage
On the land that's had our toil,
They'll not have to ask the question
"Here's the farm, but where's the soil?"

Aluminum Paints as Protective Coatings[1]

By W B Roberts[2]

PROTECTIVE paint coatings owe their usefulness largely to the property of being relatively impermeable to the passage of such gases as oxygen, carbon dioxide, water vapor and hydrogen sulphide. The life of the paint film itself depends chiefly on its inherent resistance to the attack of these agents and its ability to withstand the destructive photochemical action of sunlight.

Light-colored paints for metal are in general not durable, most of them showing a strong tendency to fail rather quickly by chalking or washing. However, with the development of aluminum paints there was made available a light-colored coating equal in durability to the darker-colored paints and possessing properties that permit its successful use under very adverse exposure conditions. The aluminum pigment differs from other types of pigments in that it is composed of flat metal flakes that have the property of "leafing." In other words, in an aluminum paint film there is a partial concentration of the pigment at the surface, caused by a surface-tension effect. This imparts a bright metallic color to the paint and is an additional barrier to the passage of moisture and oxygen and minimizes and destructive effect of sunlight. In addition each opaque metal flake distributed throughout the film reflects harmful rays, thus adding to the life of the vehicle. Aluminum paints maintain their protective qualities for long periods chiefly because the distensibility of the "elastic" vehicle remains relatively unaffected by exposure to sunlight.

The pigment of aluminum paint is manufactured by stamping to a powder, pure metallic aluminum. As a result, properly prepared aluminum paints share, in a large measure, the characteristics of the metal from which the pigment was produced. Aluminum paint shows excellent resistance to the attack of hydrogen sulphide and other sulphur compounds, salt spray, acids, and moisture, but poor resistance to the action of alkali. When applied to machinery, sheet iron buildings, and similar structures, its metallic lustre produces an attractive finish, characteristicly different than that obtained by use of other types of paint.

The vehicle used to prepare aluminum paint designed for application to metal surfaces is of the varnish type. Linseed oil, unless well-bodied by heat or unless preoxidized by air-blowing, does not work satisfactorily as an aluminum-paint vehicle. The varnish vehicle usually employed is of the "long-oil" type, being about 40 gal in length. The nonvolatile content of the vehicle should not fall much below 50 per cent if best results are to be obtained.

Aluminum paint has no rust-inhibitive properties, nor is it rust-exciting in character. It is classed as a "neutral" pigment with regard to electrolytic activity. While it gives reasonably good performance when applied on bare steel, better results will be obtained if a good inhibitive primer is used as an under coat. This is particularly true if the metal surface shows considerable evidence of rust at the time the paint is applied.

The use of aluminum paint on wood is largely confined to its application as a primer or first coat. While there are few, if any, paints that can show durability comparable to that of two or three coats of this paint, the fact that it is only obtainable in one color and does not take delicate tints readily, has limited its use as a finishing material.

As a priming coat on wood, however, it offers many advantages not obtainable with the ordinary wood primers. It has high initial moisture-proofing ability and maintains this characteristic for exceptionally long periods of exposure. The vehicle, which in this type of application consists of a long-oil varnish (65 to 80 gal in length) remains elastic and able to easily follow the swelling and shrinking of the lumber surface. This characteristic enables the paint to show the same adherence over summer wood as over spring wood, thus maintaining the integrity of the top coats at these points. The nature of the aluminum-painted surface is such that very good adherence is obtained by the top coats applied over it. There is an increase in the life of the finished paint of from one to two years by the use of the aluminum-paint primer. Since there is no tendency for the primer to flake off, an ideal surface is presented when repainting becomes necessary due to weathering away of the top coats.

Because of its characteristic metallic color aluminum paint is hard to hide with a single top coat of white or light-colored paint. Usually two coats are required for the most desirable results. However, "one-coat whites" have been prepared, with titanium oxide as the pigment, that are reasonably satisfactory if care is taken in their application. All dark-colored paints hide the aluminum color in one coat without difficulty.

If the aluminum paint is applied in two coats and left in the natural color of its pigment, it produces an attractive and distinctive finish, particularly if a dark trim, such as green or brown, is used to heighten the contrast.

The long-oil varnish used for making aluminum paint for wood application is slower drying than the type employed for metal. The film it produces is also somewhat soft. However, for general painting work on both wood and metal, the wood vehicle will give excellent service from a durability standpoint. It will not have good abrasion-resisting qualities, however, until it has been allowed to dry for several weeks. For machinery or metal barn equipment, the harder-drying varnish should be used. It must be kept in mind, however, that use of the short-oil varnishes on wood will lead to poor results, since they do not possess sufficient elasticity, and will invariably crack and peel after a short weather exposure.

[1]Abstract of a paper presented on the program of the Structures Division at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Aluminum Company of America.

Development of the Potato Harvester[1]

By R U Blasingame[2]

IN Bulletin No. 238 of the Pennsylvania Agricultural Experiment Station entitled "Farm Power and Labor" (page 18), table 11 gives an itemized list of the man-hours required to grow an acre of potatoes by common Pennsylvania practice as follows:

Operation	Man-hours per acre	Per cent
Spreading manure	6.8	6.6
Plowing	5.8	5.6
Preparing seedbed	6.8	6.6
Applying fertilizer	1.2	1.2
Marking for planter	2.1	2.0
Planting	6.7	6.5
Cutting seed	7.4	7.2
Spike-tooth harrowing (twice)	1.7	1.7
Cultivating (5 times)	9.0	8.8
Spraying (6 times)	3.4	3.3
Digging with elevator digger	4.4	4.3
Picking in crates (290 bushels)	32.5	31.6
Loading, hauling and storing	15.0	14.6
Totals	102.8	100.0

This table shows that 102.8 man-hours are required to produce an acre of potatoes with a production of 290 bushels per acre. Picking the potatoes in crates, at harvest, required 32.5 hours, or 31.6 per cent of the total time. Efficient equipment is available for twelve of the thirteen operations incident to commercial potato production. The one operation of picking up potatoes behind the digger, by hand, is antiquated, irksome and expensive. Spraying the crop six times requires 3.4 hours and cultivating five times only 9 hours.

It is thus evident that there is a need for a machine which will in part, at least, reduce the cost involved in harvesting potatoes. With these facts in mind, the late H. B. Josephson and the author began studies under Project No. 795, "Design of Potato Harvesting Machine to Meet Pennsylvania Requirements." In the fall of 1929 Mr. Josephson studied several potato pickers used by commercial growers in the state. In this manner he determined the deficiencies of this equipment and during the winter of 1929-30 designed and built the machine shown in the accompanying pictures. It consists of two wheels which straddle three rows, harvesting the center row. Mounted on the wheels is a 22-inch potato digger chain which is driven by traction from one wheel. The front end of the chain slopes at an angle to catch the potatoes, clods, vines, etc., as they come over the potato digger. On each side of the digger, platforms are arranged on which men stand. On each side of the elevator chain, and at the same level, canvas belts are arranged to convey the potatoes to a cross elevator which, in turn, conveys them to a crating device as they are picked off the chain by men on the platforms. This crating device is built to carry three crates, which are dumped similar to a sheaf carrier on a binder.

The front end of this harvester attaches to the rear end of the potato digger which allows short turning. The machine was used to harvest fifteen acres of potatoes on the college farms, in 1930, which were grown entirely with the use of a general-purpose tractor.

The season of 1930 was extremely dry; consequently the yield was low. Under these circumstances, there was little opportunity to make observations with respect to the full capacity of the machine.

To operate this machine required one man to drive the tractor, one at the front end of the picker to remove vines, grass and weeds, four men at the picking table, and one following behind the outfit to gather the potatoes which the machine failed to get.

It was necessary to drive the tractor in low gear and throttle down from 1 to 1¼ miles per hour.

Mechanical Weaknesses. The following mechanical difficulties were encountered during the 1930 harvest season:

1. Loss of potatoes at the lower end of the picker-elevator at the point where potatoes are delivered from the digger.

2. Stones wedging between the ends of the picker conveyor and the left sideboard, which was not protected by cotton webbing.

3. Stones wedging between the rod conveyor of the picker and the conveyor idler wheel and idler-wheel guard at the forward end of the picker. This occurred much more frequently on the side not protected by cotton webbing.

4. Loss of time in replacing breakpins in sprocket of picker.

5. Sidedraft of picker, because of drive from only one wheel (the right), and because it was necessary for this wheel to run in the loose ground of the row previously dug.

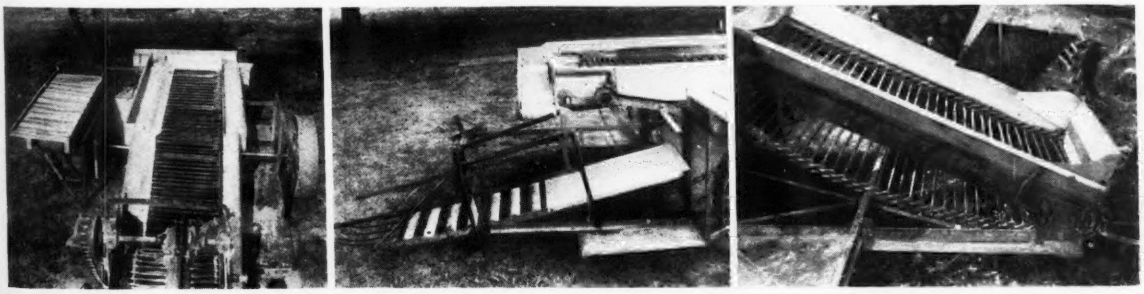
6. Crate carrier not strong enough.

7. Crate carrier too low. This caused the carrier to drag on the ground except on very level ground and tended to leave one or two crates at a place instead of three as planned.

8. The mechanism for throwing the picker in and out of gear was not strong enough.

[1]Paper presented at the Power and Machinery Division session of the 25th annual meeting of the American Society of Agricultural Engineers at Ames, Iowa, June, 1931. Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 531.

[2]Head, department of agricultural engineering, The Pennsylvania State College. Mem A S A E.



Three views of the experimental potato harvester developed in Pennsylvania

Redesign of Harvester. With the experience of 1930, this machine was rebuilt during the past winter (1930-31). The following changes have been made:

1. The rod conveyor was raised 3 inches and lengthened 18 inches.
2. Larger wheels were installed operating on a live axle and mounted on roller bearings.
3. Mechanism driven from both wheels.
4. Crating device replaced by an elevator to put the potatoes on a wagon or truck drawn alongside the machine. Unless this elevator is carefully padded there may be considerable bruising of the potatoes.
5. A valve provided to deflect the potatoes directly to the elevator where few clods and stones are present. In this case, the foreign material will be picked off the conveyor and the potatoes left. In case the foreign material is of larger volume than the potatoes the valve is adjusted to deflect the stones, clods, etc., on the ground.
6. Cone-shaped rollers or idlers at lower or front end of the conveyor rod elevator.
7. Increased speed of conveyor chain.
8. Increased speed of canvas conveyors.
9. Clearance increased 10 inches.
10. Slip clutch provided for protection of the machine parts in place of the breakpin.
11. Jaw clutch for throwing the mechanism in and out of gear.
12. Frame of the machine raised 8 inches higher off the ground.

The following table shows the amount of potatoes a harvester must handle in bushels per hour with various yields and speeds of travel where the rows are 32 inches apart:

Speed Calculations

Width between potato rows—32 inches.

Length of rows required to make one acre—16,380 feet.

Yield, bushels per acre	Feet of row per bushel
200	84.0
300	54.5
400	41.0

Miles per hr.	200 bushels per acre	300 bushels per acre	400 bushels per acre
¾	48	72	96
1	64	96	129
1¼	80	120	161
1½	96	144	194
1¾	112	168	226
2	128	192	258

Wet Litter in Poultry Houses[1]

By M Wayne Miller[2]

PROBABLY the greatest source of moisture in the poultry-house litter is that given off by the birds themselves in their droppings. The humidity of the air in the house is also increased by the breath of the birds. It has been estimated that each one hundred birds give off 3 gal of water in the 24-h period. Whether that statement is true or not is immaterial because we know that poultry-house litter becomes wet very quickly during certain times of the year. Birds drinking from the water trough naturally spill considerable water from their beaks while drinking, and during rainy weather it is surprising to know how much of the water actually comes from leaks in the poultry house roof. During rainy weather the humidity of the outside air is very high, and as the ventilating system moves the air from the inside of the house out, it follows that the air from the outside must be drawn in through the intake opening. Therefore, there is very little opportunity for the moisture which is in the litter to be evaporated and taken up by the air. When winds accompany rains, there is a possibility of a certain amount of moisture being blown into the poultry house. This clarifies the situation as to where the moisture comes from.

Now the problem is, how to get rid of it. In the fall of 1929 a housing experiment was undertaken at the Western Washington Experiment Station. The plan of the experiment involved the remodeling of some of our open-front houses in such a way that the front could be closed. Certain pens also were insulated to various degrees. In planning the experiment we were working upon the theory that, if we could make our houses warmer through insulation and restricted ventilation, we would make them drier. We felt that this would be true, because we knew that warm air has a greater moisture-carrying power than does cold air. The plan of the experiment was essentially, as follows:

A house was divided into three pens. In the first the house was left as it had always been, with the open-front and the sky-light ventilators. A double roller curtain made possible a partial closing of this front. The second pen was constructed in such a way that it was possible to close the front with cel-o-glass frames. The sky-light ventilator was removed and a shaft ventilator used in its stead. The shaft ventilator consisted of a wooden flue 12 in square. Two of these flues were placed in a 20x30-ft section. A third pen also had the front closed and shaft ventilators installed. In this pen the rear wall was insulated and the house was ceiled with a wooden ceiling.

Two hundred pullets were placed in each of these three pens, and these pullets were selected in such a way as to have the various lots to be as nearly as possible identical. Temperature and humidity readings were taken in each of the pens. The measurement of the air movement through the shaft ventilators was also recorded.

At the end of the first year of the trial, we were quite surprised to find that the litter became wet quickest in the insulated and closed pen, and that it remained dry longest in the open type of laying house. The ceiled pen and the closed-front pen both showed a higher average temperature and a lower variation in temperature from day to day. Egg production was just as high in the open-front house as in the ceiled and closed houses. No appreciable difference in mortality was recorded. The trial was repeated the following year and results served to substantiate the results of the first year's trial. Apparently the only difference between the three pens was in the matter of the length of time that it took the litter to become wet.

Some will probably immediately raise the question as to whether the ventilation in the pens which were closed and the one which was ceiled was adequate. Anemometer reading taken in the air shaft showed that, even when the ventilators were pulling the least amount of air recorded, the change was quite sufficient to abundantly supply the

[1]Paper presented on the program of the Rural Electric Division at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

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One of the greatest factors causing wet litter in poultry houses is condensation. A cold floor condenses moisture from the air above it and gives no opportunity for moisture in the litter to evaporate. Increased ventilation does not solve the problem. Insulation increases it. Floor heating does solve it.

oxygen necessary. Air shaft readings gave a minimum change of air at least once in 20 min. When the ventilating conditions were more favorable, the air change was more frequent.

Perhaps at this point it might be well to discuss the conditions that are favorable for a rapid pull of air through the shaft ventilators. Possibly the greatest single factor in determining the amount of air that the shaft ventilator will pull is the wind velocity. The higher the wind velocity, the faster the air movement through the shaft. The greater the difference between the temperature on the inside of the house and on the outside, the greater will be the movement of air through the shaft. If the wind velocity is constant, the shafts will pull faster if the wind is blowing against the front of the house, than if the wind is blowing against the back of the house.

The three factors then — wind velocity, temperature difference, and wind direction—are responsible for the variation in the volume of air moving through the shaft ventilator.

At the end of the two-year trial in poultry housing we felt that we were attacking the problem from the wrong angle. In other words, we were trying to build a poultry house that would produce dry litter without understanding the conditions that caused wet litter. So in the fall of 1931 the project was again continued but this time in a different location and with a different plan of procedure.

The purpose of the new project was to determine (1) the effect of heat applied to the floor of a poultry house, and (2) whether or not air movement or ventilation would help prevent wet litter in poultry houses. In addition to these two objects certain modifications were planned in case either of the two were successful.

In discussing the experiment perhaps the best way to do it is to start with the first factor and continue on in the order in which the trials were conducted. The house used for the experiment was a 24x24-ft gable-roofed, ceiled, and insulated house. The insulation consisted of a 4-in thickness of shavings between the studding of the house and a 6-in layer over the ceiling. The ceiling was 6½ ft from the floor.

In order to study the effect of floor heat on dry litter, it was necessary to construct a double floor and to circulate warmed air between the two floors. The floor joists were staggered in such a way as to allow a continuous circuit of air. The circuit was closed by the use of air ducts and a fan used to keep the air in circulation. Within the circuit were placed heating elements so that it was possible to introduce any amount of heat under the floor as was desired.

In the first trial conducted we used the heat from a 500-w electric heating unit, circulating the air under the floor. Temperatures of the air under the floor and of the air just above the floor were recorded on a recording thermograph. Also humidity conditions were recorded inside of the house and also outside. The house was ventilated through two 12-in shaft ventilators. Daily readings were taken in these shafts to determine the amount of air removed from the house. It was found that the temperature under the floor was 7 deg warmer than the temperature of the air just above the floor.

The litter remained dry for three weeks at which time the litter was changed. At three weeks the litter was perfectly dry and indicated that it would be possible to keep the litter dry indefinitely. During the three weeks of the experiment few days passed but what some precipitation was reported. In other words, the weather conditions were very bad. Incidentally the house used in this trial was the same house that was used last year, and it was found last year that the litter became wet in about seven days.

At the end of this trial cold air was circulated under this floor and the litter became wet very quickly. This would indicate that one of the greatest factors causing wet litter in the poultry house is that of condensation. In other words, the floor becomes cold and condenses moisture from the air on the floor, and when this condensation is taking place there is practically no opportunity for the moisture in the litter to be evaporated into the air.

The second trial to be conducted was to determine whether it would be possible to remove by use of the fan the warm air from the ceiling of the house, circulate it under the floor and thus ventilate and warm the floor at the same time. Air ducts were constructed in such a way as to make this possible. In this experiment it was found that the litter remained dry longer than it did under similar conditions without this method of floor heat. However, the litter did not remain dry indefinitely. So that we now consider it impractical to heat the floor with the heat of the birds themselves.

The third experiment consisted of drying the wet litter used in the second experiment by heating the floor. It was possible to dry the litter in three days of heating the floor, heating the air under the floor to about 100 deg. However, this required 6000 w for the full 24-hr period. This indicated that it required much more heat to dry litter that is already wet than to keep litter dry that is dry to start with.

The fourth experiment was designed to determine the effect of rapid ventilation on the wet-litter problem. Floor conditions were normal; however, a fan was placed in a ventilator shaft that removed nearly 2000 cu ft of air per minute. It completely changed the air in the house in less than 2 minutes. The air was removed 12 in from the floor. At the end of ten days the litter was wet.

In the next experiment the same fan was used to remove the air from the ceiling of the house. In ten days the litter was again wet, indicating that the rapidity of air change during bad weather conditions will not produce dry litter. Whereas, heat under the floor will effectively do so.

Subsequent trials merely substantiate the results obtained in the trials reported above. It is interesting to note that during eleven experimental periods the average relative humidity within the house never was below 70 per cent, and in the trial where the relative humidity was the lowest, the litter became wet when the floor was not heated, indicating that in all trials conditions were such that wet litter would have resulted if normal conditions had prevailed. There was some precipitation recorded on over 68 per cent of the days covered by the eleven trials.

The conclusions which may be drawn from the 2½ years' work on the poultry housing at the Western Washington Experiment Station would be

1. That forced or natural ventilation helps very little in keeping litter dry during wet weather.

2. The warmer houses are built, the wetter they become because of the condensation of the moisture from the warm air of the house on the cold floor.

3. Floor heat overcomes the condensation problem and also supplies enough heat to facilitate the evaporation of moisture from the litter, thus keeping it dry.

Floor Heating for Brooder Houses[1]

By Hobart Beresford[2]

IN 1931 the department of poultry husbandry at the University of Idaho, in cooperation with the department of agricultural engineering built an experimental brooder house in which a floor section 4 ft wide extending the length of the house was omitted for the purpose of carrying on experiments with electric floor-heating equipment.

After considerable experimental work, two floor-heating units finally were placed in operation in the brooder house. The two concrete units were 4 in thick and 4 ft square and were made with a ¼-in square steel reenforcing basket as shown in the accompanying sketch. In each of the units 60 ft of hotbed or soil-heating wire was embedded about ½ in from the upper surface of the slab. In addition to this soil-heating wire the bill of materials for these floor-heating units included 1½ sacks of portland cement, 5.3 cu ft of sand, 55 ft ¼-in square steel reenforcing rod, one standard outlet box, and a 3-in section of ½-in conduit.

Experimental slabs were constructed using several variations in the spacing of the heating element and using plaster board and insulating material for the construction of the slab. One slab was made in which the soil-heating wire was embedded in asbestos plaster supported by an insulated frame, the entire slab being covered with a galvanized iron case. The operating characteristics of the different floor-heating units showed those made of concrete to be the most desirable both from the standpoint of the heat distribution and the storing of heat which is a decided advantage where service interruptions occur. The floor-heating units made of concrete required from 6 to 8 hr to reach their maximum temperature and retained their heat from 3 to 4 hr after the current had been turned off.

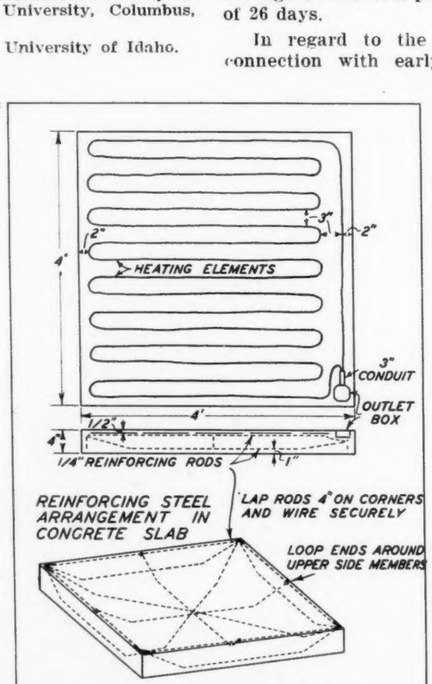
The first attempted use of this floor-heating unit was made with the idea of providing sufficient heat from the warmed floor to produce a comfortable condition under the standard-type, conical-shaped hovers. It was found that, in order to raise the temperature of the air under the hover which was located in a house at 40 deg (Fahrenheit), it was necessary to bring the slab to between 125 and 130 deg. Even though the chopped wheat straw litter furnished some protection for the chicks, the concrete slab was too hot for comfort, and the idea of being able to heat the area under the hover from a uniformly heated slab was abandoned.

The next idea carried out in the experimental work was to rearrange the heating element in such a way that a concentration of the heat would occur in the center of the area and gradually taper off to the outer edge, providing a varying range in temperature in order to meet the requirements for the chicks. This attempt was unsuccessful, and the opinion of our poultryman is that the application of heat to the floor does not produce the most desirable living conditions for the chicks. In other words, some supplemental heat is desirable.

The correctness of this opinion was demonstrated by a later experiment in which two of the floor-heating units, each containing 60-foot elements, were connected in series on a 110-v circuit and used in conjunction with standard types of electric hovers. One 4x4-ft slab was used under each of the 300-chick capacity hovers for brooding a total of 534 White Leghorn chicks for a period of 26 days. The temperature of the concrete slab averaged from 80 to 90 deg, depending upon the weather conditions, and kept the floor and litter warm and dry at all times. The energy consumption during the brooding period averaged 5.73 kwh for a day of 24 hr for the two slabs, or 2.86 kwh per slab per day. The total energy consumption for the brooders operating in connection with this experiment showed an average of 7.76 kwh per day for each hover during a period of 26 days.

In regard to the use of the floor-heating units in connection with early brooding C E Lampman[3] states that where electric hovers were used with the floor-heating units ideal hover conditions were secured. The use of the electric hover for early brooding usually has been accompanied with a problem of damp litter especially where the floors are cold and when liquid milk is fed in the chick ration. Damp litter also has been attributed to faulty ventilation of the hover which results from an attempt to conserve the heat during the cold weather encountered in early brooding. Prof. Lampman further states, "Our experience has been that when we have no floor heat we usually get some moisture in spite of our efforts to maintain the best possible ventilation under the hover. When we used the electric floor heat, we had a condition that was very beneficial from the standpoint of sanitation and disease control."

Electric heating elements imbedded in reinforced concrete slabs provide a brooder floor which will keep the litter dry. Other supplementary heat is necessary, however, to maintain proper air temperatures under the hover without raising the floor temperature too high or restricting ventilation



FLOOR HEATING UNIT

[1]Paper presented on the program of the Rural Electric Division at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Professor of agricultural engineering, University of Idaho. Mem A S A E.

[3]Professor and head of the department of poultry husbandry at the University of Idaho, and who cooperated with the department of agricultural engineering in the floor-heating trials.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Electric Hotbeds, Cold-Frames, Propagating Benches, and Open Soil Heating, I, II, G. W. Kable ([C.R.E.A.] National Rural Electric Project, College Park, Md., report 5 (1932), pp. 8, figs. 12; 6 [1932], pp. 9-36, figs. 23).—This report is in two sections.

I. Recommended Construction and Use.—This section of the report presents briefly the majority opinion of many investigators relative to the advantages, the best type of construction, and the correct methods of using electrically heated hotbeds, coldframes, and propagating benches, based upon present knowledge. Much of the information, which has been summarized in cooperation with the Committee on the Relation of Electricity to Agriculture, has been secured from several of the state experiment stations and from the U.S.D.A. Bureaus of Agricultural Engineering and Plant Industry.

II.—Investigations and Research.—This section presents a summary of experimental results and investigations under way relating to hotbeds, coldframes, propagating benches, greenhouses, and open soil heating. The information has been secured from various sources, including several of the agricultural experiment stations and the U.S.D.A. Bureau of Agricultural Engineering. A description also is given of experiments being conducted by the Committee on the Relation of Electricity to Agriculture, in cooperation wtih the Maryland Experiment Station, on the relative efficiency of over-heat and under-heat for hotbeds.

It was found that under the existing temperature conditions it was entirely feasible to grow a variety of plants successfully with electric heating elements either above or in the soil. Plants in the electric beds came through the ground more quickly than those in the manure bed.

While the plants were poor in the center and at the edges of the over-heat bed, and the growth was uneven, those plants in the optimum temperature zone grew best of all, and the relatively small excess of current used over the underheat bed made further experiments with this type of heat desirable. Even with the uneven spacing of the electric elements in the underheat bed, the growth of plants evened up nicely and was more uniform than in the manure bed.

The thermostats controlling the time when current was on and off acted very much in unison in the two electric beds except at outside temperatures around 60 deg (Fahrenheit) when the thermostat in the over-heat bed snapped on first and remained on longer. Heated soil produced better roots than where heat was supplied above the soil, and the underground wiring system to the beds was especially satisfactory.

Further studies showed that heating elements placed above the soil will warm the soil and hold the top 2 in and the air at approximately the same temperatures. Placing the heating elements 6 in deep in the soil results in rather wide variations in bed air temperatures. By combining over and under heating and varying the depth of heaters in the soil, a great variety of seedbed, air, and soil temperature effects may be secured. The tentative conclusion is that under-heat hotbeds should be used at the present time.

Some results also are presented from studies at the Maryland Experiment Station on frost protection in coldframes by electricity. In this connection the heating elements accomplished their purpose in protecting plants against possible damage from cold and at a reasonable cost for power. However, an attempt to raise the soil temperature to hasten growth during the first two weeks was a failure because of excessive rainfall.

A list of desirable additional investigations is included.

The Use of Artificial Illumination for Grading Grain, D. C. Rose (Canada Journal of Research [Ottawa], 5 [1931], No. 1, pp. 64-78, figs. 7).—This paper is a contribution from the National Research Laboratories at Ottawa, Canada.

The first part is a description of artificial lighting units designed to give a suitable illumination for grading grain. Two types of illumination are under test, including the imitation of daylight by means of daylight lamps and the use of colored lights which emphasize the bad and good points in wheat. It has been found that a combination of a mercury lamp, a neon lamp, and a type S-1 sun lamp gives promise of being a satisfactory source of illumination of the second type.

The second part of the paper describes experiments which comprise an attempt to find a more objective means of grading wheat. The light reflected from wheat of different kinds and different grades was analyzed both spectroscopically and by means of a photo-electric cell and light filters. In the spectroscopic measurements ultra-violet light was included. The results indicate a certain amount of selective reflection, but the variations with the different grades are not of a nature which would be helpful in grading wheat.

Preservation of Indian Timbers—the Open Tank Process, F. J. Popham ([Indian] Forest Bulletin [Calcutta] 75 (1931), pp. [3] + 12 + [5], figs. 6).—Practical information is given on the preservation of Indian timbers by the open tank process. The process is described and is illustrated in an appendix, and second and third appendixes give lists of species which can not be treated in the heartwood and which can be treated throughout by the open tank process.

Preserving Foodstuffs by Quick Freezing and Refrigeration (New York Food Industries, 1931, pp. 240, figs. 125).—This is a selection of articles reporting modern practice in the scientific and technical control of refrigeration, quick freezing, and cold storage machinery and equipment.

Mower Investigations [trans. title], W. Kloth (Die Technik in der Landwirtschaft, [Berlin] 12 (1931), No. 8, pp. 232-235, figs. 4).—Experiments conducted at the Agricultural Academy of Berlin are reported. The results are taken to indicate that the value of oil bath construction for mowing machines in agricultural use has been overestimated and that these machines in such use do not have an especially high efficiency. Doubt is cast on the justification for the higher price of these machines, especially when the short period of annual use is considered.

Flood-Water Farming, K. Bryan (The Geographical Review, [New York] 19 (1929), No. 3, pp. 444-456, figs. 9).—In a contribution from Harvard University, results of a general study are briefly summarized on the geographical relationships of the practice in flood-water farming. Consideration also is given to the decline in acreage in relation to recent changes in stream channels. No specific conclusions are drawn.

Nature, Cause, and Prevention of Carbonaceous Dust Explosions and Fires, H. Steinbrecher (Wesen, Ursachen und Verhutung der Kohlenstaubexplosionen und Kohlenstaubbrande. Halle [Saale]: Wilhelm Knapp, 1931, pp. VIII + 77 + [1], figs. 8).—This book brings together the results of numerous studies from various sources relating to the nature and cause of fires and explosions of carbonaceous dusts, and gives both technical and practical information on their prevention.

The conclusion is that the explosibility of carbonaceous dust is a function of its concentration, fineness, inflammability, and speed of combustion. The content and composition of volatile constituents, the content of water and ash, and the amount and intensity of the combustible constituents also are factors of importance in explosibility. The spontaneous combustion of carbonaceous dusts also is considered to be a source of danger which is underestimated in that it may result in a serious explosion. General and special rules for the handling of carbonaceous dusts are included.

Effect of Calcium Chloride as an Admixture in Portland Cement Concrete, R. C. Sloane, W. J. McCaughey, W. D. Foster, and C. Shreve (Ohio State University Engineering Experiment Station [Columbus] Bulletin 61 [1931], pp. V + 81, figs. 31).—Results of studies are reported which showed that calcium chloride retards the hydration of tricalcium aluminate and tends to keep the hydrated material in an amorphous or finely crystalline condition. It accelerates the hydration of the tricalcium silicate and slightly accelerates the hydration of the beta dicalcium silicate. Calcium chloride accelerates the hydration of portland cement up to 3 days, and after about 30 days, and is partly used up in the hydration of cement. It tends to make a silica gel, such as coats a partially hydrated cement grain, much less permeable, and is positively adsorbed by the cement grains.

When cured in air, mortars treated with calcium chloride lose less water than plain mortars. Concrete treated with calcium chloride shrinks more than plain concrete from the first to the tenth day.

Dust Explosions (Journal of the Society of Chemical Industry [London], 50 [1931], No. 31, pp. 650-653).—This is an abstract of a lecture presented at the Home Office Industrial Museum, Westminster, covering a review of results of experiments conducted elsewhere relating to dust explosions and reporting the results of some experiments with grain dusts, particularly from grains stored in bins. It was found that bin storage of grain represented an improvement from the standpoint of dust explosions. Tall vertical silos appeared to give the best results in this respect.

Experiments were also made to determine to what extent the top of a silo should remain open to relieve pressure in the event of an explosion, a silo 90 ft high and 10 ft or more in diameter being used. It was found that when the top of the silo was fully open the pressure produced by an explosion of rice meal dust was too small to be measured. When the top of the silo

(Continued on page 246)

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Speculation in Work Animals

PROPAGANDA to the effect that farmers will find it profitable to raise more work animals is deflated, in our judgment, by a study of costs and of the probable future market which has been made by the National Association of Farm Equipment Manufacturers.

The Association speaks as the representative of manufacturers of horse-drawn as well as of tractor-drawn equipment. It calls attention to many considerations and leaves the reader to form his own conclusions. It distinguishes between the evident desirability of making full use of existing work animals during the present agricultural price, cash, and credit stringency; and the speculative proposition of breeding mares now, investing money over a period of three or four years, and hoping for an animal-power market at that time which will justify the investment. It grants that "if production of work animals is going to be profitable, farmers should not miss the opportunity."

Data presented show that at present prices the cost of raising a colt would be slightly under $100, practically the same as the present market price for good 5-year-old horses; that at the present price 8 horses, with harness, etc., represent a greater investment and cost more to maintain than does a general-purpose tractor which will do the same amount of work.

It is pointed out, however, that the price trend of work animals for the next three or four years will depend largely on whether the tractor market has reached its saturation point, whether the farm motor truck market has reached its saturation point, and whether or not farmers will go back to the horse and buggy as a means of personal transportation. Considerations under these main points are the possibility of further improvements in and lower prices for mechanical power devices; the possibility that the present "back-to-the-farm" movement will be of short duration, and the possibility that the cash position of farmers may be enough better that all who have tractors will be able to buy gas and oil to operate them, or enough worse that they will not be able to buy horses.

The Association's study is informative and apparently fair to the horse and its advocates. It is well worth the reading of farmers who may be considering the raising of more work animals, and of all persons who take an interest in the perennial horse-tractor controversy.

An Engineering Outlook

A RECENT ARTICLE, entitled "Product Design for the Market,"[1] states some viewpoints which, if interpreted broadly, seem as applicable to agriculture as to the manufacturing industries.

"A great many of our business problems," it explains, "have their origin in our failure to distinguish between the purpose of our industrialism—a higher standard of living for society as a whole—and its motivating force—profits for the individual. The purpose of the automobile is to furnish transportation; its motivating force comes from the gasoline in the tank. To say that the purpose of the automobile is to encourage the use of gasoline is obviously to put the cart before the horse. Yet, the actions of many industrialists seem to testify to a belief that business exists for certain ends of its own, and that the consumer's true place in the picture is to provide the fuel which runs the industrial machine."

Where has the emphasis been placed in agriculture? Basically, is the agricultural problem one of combining in restraint of trade to force a reapportioning of the benefits of that highly variable grand aggregate of humanly useful productivity which is known as the "national income"? Is it one of fueling the agricultural machine—irrespective of the low average quality of its products, its low efficiency, and its waste of natural resources (by erosion)—with tribute from the great, gaunt, hungry, ill-clad bulk of the non-agricultural population?

Or is the farm problem one of designing and providing improved products at lower cost for the consumers by whose necessity farming exists—one of providing foods, fibers, and raw materials for the organic chemical industries, so efficiently, with such regard for human values and for natural resources, that while farmers are increasing their profits society as a whole may raise its standards of living?

Cooperative Research

BEN D MOSES has applied and advocated[2] agricultural engineering research in cooperation with agricultural scientists on bases both of old and proven philosophy in human relationships, and of characteristics inherent in the work of applying engineering to agriculture.

Of the human relationships he says, in part, "Probably one of the chief barriers to the agricultural engineer's obtaining cooperation has been his seeming anxiety to establish agricultural engineering as a profession. The best way to overcome prejudice, if it exists, is for the agricultural engineer to be willing to gain recognition, not by propaganda or self-advertising, but by doing useful work and then generally recognizing, both in attitude and in publications, the contributions of others. It is only fair to place credit where credit is due, and to be humble in our personal claims."

And the following shows his thought on the characteristics of agricultural-engineering research which demand cooperation: "Seldom does the agricultural engineer encounter a research problem limited to his own field; he must work either directly or indirectly in cooperation with scientists in the different branches of agriculture. . . . . . . The agricultural engineer should not be discouraged by the complex relationships involved . . . . . but should make the work so cooperative that no authorities will question the results . . . . Some projects are necessarily of a cooperative nature because they affect public health or come under legal regulation."

[1] "Mechanical Engineering," Vol 54, No 8 (August 1932)

[2] "Agricultural Engineering Research in Cooperation with Other College Departments," an address (not yet published) before the College Division session at the 26th annual meeting of the American Society of Agricultural Engineers, at Columbus, Ohio, June 1932, by Ben D Moses, associate professor of agricultural engineering, University of California.